VUF-1008
FINAL REPORT

VELA UNIFORM

PROJECT SHOAL

SPONSORED BY THE ADVANCED RESEARCH PROJECTS AGENCY OF THE DEPARTMENT OF DEFENSE AND THE U.S. ATOMIC ENERGY COMMISSION

FALLON, NEVADA
OCTOBER 26, 1963

WEATHER AND SURFACE RADIATION PREDICTION

U. S. Weather Bureau

June 1964 A. N. Hull – R. W. Titus – H. F. Mueller

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WEATHER AND SURFACE RADIATION PREDICTION

by

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U. S. Weather Bureau

June 1964

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ABSTRACT

The Weather and Surface Radiation Prediction Unit commenced preliminary weather observations at the SHOAL Site in August 1962. Sufficient data was collected to insure statistical significance. Commencing on D-30, a complete weather analysis and forecasting unit was in operation at the SHOAL Site. The weather facilities, observation schedules, detailed pre-shot weather and radiation forecasts, and their verification are discussed.

CHAPTER I

INTRODUCTION

1.1 OBJECTIVES

Proper evaluation and minimization of the potential radiation hazard, associated with the possible venting of radioactive materials from the SHOAL underground nuclear detonation, required the utilization of meteorological facilities for measuring and predicting atmospheric conditions. The complement of the Weather Observation and Prediction Unit varied from intermittent observations by 3 meteorological technicians, commencing in January 1963, to a complement of 13 (meteorologists, aids and technicians) from D-1 to the time of the actual event.

1.2 FUNCTIONS

A primary responsibility of the WBRS, Las Vegas, Nevada, was the maintenance of a meteorological service at the SHOAL Site with the capability of preparing and issuing forecasts of meteorological elements pertinent to test activities and estimates of possible radiation exposure resulting from venting. These forecasts were made available to the Test Manager and his Advisory Panel in formal briefings on October 25 and 26, and in informal briefings at the Weather Trailer Office in the CP Area during the period D-21 until shot-time. The unit was responsible for the interpretation of meteorological data and for advising test personnel on matters influenced by the state of the atmosphere.

1.3 ORGANIZATION

The Weather Observation and Prediction Unit was under the operational control of the Test Manager. Responsibility for the Weather service was delegated by the Scientific Advisor to the Weather Prediction Unit, with the Meteorologist-in-Charge, WBRS, Las Vegas, Nevada, acting as chief of the unit. Technical personnel and supervision were provided by the U.S. Weather Bureau.

The Weather Observation and Prediction Unit worked in close cooperation with the Radiation Prediction Unit in order that the Safety Program would have the benefit of the most accurate, up-to-date and useful information possible.

The Weather Observation and Prediction Unit consisted of observation personnel that operated the upper air sounding stations and processed meteorological data, equipment maintenance personnel responsible for preventive and repair maintenance of all forms of equipment, and forecasting and briefing personnel responsible for the accurate and timely forecasts of pertinent meteorological parameters.

CHAPTER II

2.1 OBSERVATIONAL PROCEDURE

From the climatological data obtained from surface wind instruments, plus the upper air records from NAAF, Fallon, Nevada and upper air data obtained by WTRS personnel at intermittent intervals covering all seasons, it was determined that the most probable meteorological conditions that would occur during most seasons would be northwesterly winds at the GZ surface, gradually shifting to southwesterly winds above 8000 feet MSL. (See Figure 2.1 - 2.3). From these data a ground zero site as well as two off-site pibal stations was selected in the most probable downwind sector. Pibal Station #1 was located at the intersection of the Scheelite Mine Road and the Shoal Site Access Road. Pibal Station #2 was located one mile north of Highway 50 on the dirt road extension of the Scheelite Mine Road.

The two off-site Pibal Stations afforded excellent statistics on low level winds on the Fairview Valley and, with simultaneous data from the ground zero site, the ability to provide reliable short range forecasts of the wind field in the vicinity of the SHOAL Site and Fairview Valley was established.

In the event that a wind regime other than that described above were to exist on D-Day, two alternate pibal sites were selected and samples of upper air data were collected intermittently for climatological statistics. Pibal Station #3 was located at the salt mill in Fourmile Flat. Pibal Station #4 was located alongside U.S. Highway 50, 15 miles west-northwest of the Scheelite Mine Road intersection.

Prior to D-30, intermittent sampling of upper air data was conducted to determine the topographic effects on the lower level winds and to statistically compare the wind field above the surrounding topography with simultaneous upper wind observations taken at NAAF, Fallon in order to determine at what levels the wind fields were nearly identical. The data collected implied that the seven year record of wind statistics at 8000 feet MSL and above would apply to the SHOAL Site. The levels below 8000 feet MSL were definitely affected by the local topography. The proper location of downwind off-site pibal stations greatly alleviated the low level forecasting problem.

Commencing on D-30, simultaneous hourly upper wind observations from 0600-1300 PDT were taken at GZ and one off-site pibal station. This schedule was expanded to include both off-site pibal stations commencing on D-21.

On D-14, and continuing through D-Day, the GZ observations were made from the M-33 radar located below CP alongside the

the CP Access Road.

On D-7, and continuing through D-Day, upper air pressure, temperature, and humidity observations were taken at 0730 PDT and 1000 PDT to augment the hourly upper air wind field data.

On D-4, and continuing through D-1, smoke pot observations were conducted at 1200 PDT at GZ to determine low level trajectories under northwest surface wind conditions. On D-Day these observations were conducted from the radar site at 0715, 0815, 0915, and 1115 PDT using tetroons (constant level balloons).

One surface wind speed and direction instrument and recorder was installed on the Communications Microwave Tower on the peak, approximately two miles southwest of ground zero. This instrument was so located to obtain as nearly as possible the true surface wind free of terrain effects. The other surface wind speed and direction instrument and recorder was installed approximately 500 feet west-northwest of ground zero.

In early October the two wind instruments were telemetered to the Weather Bureau Trailer at the CP Site in order to have the wind data immediately available to the forecaster.

Radio and telephones were used to disseminate weather information on-site. Off-site upper-air data were transmitted by radio communications. Tabulated weather data covering the event were distributed to principal participants immediately after the event. Post-shot trajectories were computed and disseminated to USPHS and AFTAC until H+24 hours.

2.2 ANALYSIS PROCEDURE

Prior to D-30, local surface and upper air data were used to compile statistics on the general monthly wind and temperature pattern at the SHOAL Site. Commencing on D-30, facsimile charts were the major source of information required for general forecasting. These were supplemented twice daily by more detailed analysed surface and upper air charts from teletype data, and daily time cross-sections of the upper air wind, pressure, temperature, and humidity patterns from SHOAL Site observations were utilized as aids to detailed local forecasting.

Commencing on D-7, surface weather charts, the wind fields at 2000 feet above the surface, and the wind field at 10,000 feet MSL were analysed every six-hours.

2.3 WEATHER BRIEFINGS

The weather briefing was formally presented to the Advisory Panel by the Briefing Meteorologist. Briefing charts and forecasts used in the presentation were prepared by the Briefing Meteorologist assisted by the Project Officer. The final decision on the forecast and the briefing charts was the responsibility of the meteorologist giving the formal briefing. Briefing materials were graphical displays (Figures 2.4 and 2.5) of the:

10,000-foot prognostic streamlines for H-hour, with forecast trajectories to 48 hours for the 2nd standard level above the surface and to 24 hours for 10,000 feet MSL; clouds and weather for the period H-4 to H+8; and winds aloft and surface wind forecasts for ground zero bracketing shot time. Also included were the event forecast temperature sounding and wind profile to 14,000 feet MSL.

A daily forecasting service was maintained at the SHOAL Weather Trailer. Event briefings were prepared separately. One briefing was held in Fallon at an AEC conference room at 1300 PDT the day prior to the event; the second follow-on briefing for the Advisory Panel was held in the Test Manager's Trailer at H-2 hours. The final shot-time wind forecast in 1,000-foot increments up to 10,000-foot MSL was completed one hour prior to briefing time and given to the forecaster from the Radiation Prediction Unit.

After the pre-shot briefing, the Briefing Meteorologist monitored the latest incoming wind and weather data and interpreted additional data as necessary both before and after detonation. With venting a possibility at shot and after, the services of the Briefing Meteorologist were available to commence tracking activities and trajectories associated with any nuclear cloud resulting from such venting.

CHAPTER III

RESULTS

3.1 WEATHER CHRONOLOGY

During the period September 26 through October 23, extremely persistent weather conditions prevailed, characterized by abnormally warm and dry weather throughout the United States. During this period winds at the SHOAL Site were southeasterly from the surface up to approximately 10,000 feet MSL, an unacceptable direction since the winds were directed towards Fallon. On October 24th a rapidly developing low pressure area moved into the Gulf of Alaska and was headed toward the Washington-Canadian Border. An active cold front passed the coastline in Washington the afternoon of October 24th, bringing torrential rain and high winds as far south as the North California Coast. The speed of this cold front was determined by successive hourly plots and, by 1100 PDT, October 25, it was determined that the front would pass through the SHOAL Site late on the 25th or early morning the 26th (See Figure 3.1). At this time it was also noted that the southern portion of the cold front, after passing the coastal mountain barrier, was producing progressively less amounts of precipitation. Based on the above, a forecast was issued for near perfect conditions to prevail at H-Hour the morning of the 26th.

The surface front passed through the SHOAL Site at 0215 PDT, October 26, indicated by a sudden wind shift at the surface from south to northwest. Overcast skies prevailed until 0430 PDT, than rapid clearing occurred. By 0700 PDT, surface winds were steady northwest 8-12 MPH, with clear skies. Winds aloft indicated approximately a 60 degree wind shear aloft becoming southwest 20-25 knots at 10,000 feet. A temperature sounding at 0700 PDT indicated the front aloft to be at approximately 7500 feet MSL. Using normal slope for a frontal surface this indicated the front was at the surface (3000 feet MSL) approximately 50-75 miles southeast of the SHOAL Site. This was verified upon analyzing the 1200Z (0500 PDT) surface weather chart. (See Figure 3.3).

Figures 3.1 through 3.4 show the continuity of the surface weather charts. Figure 3.5 is a streamline analysis of the 10,000-foot wind at H+1 hours indicating a moderate southwesterly wind field above the SHOAL Site.

Table 3.1 below indicated the measured mean layer winds observed on 24-26 October with the potential fallout arcs measured in degrees true from GZ and the angular width of the potential fallout area.

3.2 WIND FORECAST VERIFICATION

One method of obtaining a measure of forecasting skill is to compare the forecast made by the Briefing Meteorologist with a "persistence forecast" made by the wind sounding prior to the

TABLE 3.1

MEAN LAYER WIND SUMMARY 24-26 OCTOBER 1963

	SURFACE TO 8000' MSL (2800' Above GZ)	SURFACE TO 10000' MSL (4800' Above GZ)	FALLOUT BEARINGS FROM GZ MEASURED CLOCKWISE	ANGULAR WIDTH
24 0700 PST	208/1.5	278/2.5	310-098	(148°)
24 1000 PST	177/5.0	236/5.0	280-056	(136°)
24 1200 PST	087/3.0	220/1.5	140-040	(260°)
25 0700 PST	292/4.0	276/9.5	096-310	(214°)
25 1000 PST	274/5.5	264/8.0	084-130	(46°)
25 1200 PST	277/7.0	259/12.0	079-132	(53°)
26 0400 PST H-5	292/10.0	270/13	090-138	(48°)
26 0500 PST H-4	300/8.0	276/11.5	096-140	(44°)
26 0600 PST H-3	310/7.0	279/10.0	080-140	(60°)
26 0700 PST H-2	313/6.5	281/10.0	080-145	(65°)
26 0800 PST H-1	330/4.5	277/8.5	097-176	(79°)
26 0900 PST H-Hour	340/5.5	277/7.0	097-176	(79°)
26 1000 PST H+1	325/3.0	272/7.0	092-165	(73°)
26 1100 PST H+2	320/2.0	276/5.0	096-165	(69°)
26 1200 PST H+3	315/1.5	271/6.0	091-147	(56°)
26 1300 PST H+4	320/3.0	280/6.0	101-152	(51°)
26 1500 PST H+5	320/5.0	290/7.0	110-143	(33°)

briefing with both projected to the actual event time and compared with shot time winds.

The briefing wind forecasts and persistence wind forecasts are compared to the actual shot time winds in Table 3.2, and error evaluations are made for each level in speed and direction.

Event Name: SHOAL

Event Date: October 26, 1963

Event Time: 1000 PDT

Radar Run : 0900 PDT

Briefing Date 0800 PDT
October 26, 1963
for 1000 PDT

Briefing Date 1300 PDT
October 25, 1963
for 1000 PDT - October 26

			1400 Z	Error	Error		1900 Z	Error	Error
Height MSL (1000')	Observed Wind Dir Spd	Predicted Wind Dir Spd	Persistence Wind Dir Spd	Predicted Wind Dir Spd	Persistence Wind Dir Spd	Predicted Wind Dir Spd	Persistence Wind Dir Spd	Predicted Wind Dir Spd	Persistence Wind Dir Spd
10	260 23	270 25	260 20	10 02	0 03	260 25	260 20	0 02	0 03
9	260 19	270 20	268 21	10 01	8 02	270 20	250 20	10 01	10 01
8	270 07	270 15	270 11	0 08	0 04	270 15	260 11	0 08	10 04
7	360 06	320 15	327 07	40 09	33 01	280 15	260 05	80 09	100 01
6	350 03	320 10	337 07	30 07	13 04	290 10	250 03	60 07	100 00
SFC 5233'	310 07	310 05	343 06	0 02	33 01	310 05	310 08	0 02	0 01

NOTE: Directions in Whole Degrees

Speeds in Whole Knots

Table 3.2 WIND VERICATION DATA

3.3 RADIATION CHRONOLOGY

The SHOAL experiment was designed to completely contain underground all radioactive materials produced by the detonation. Based on previous experience, the 1200-foot burial depth of the device was sufficient to prevent a blowout through the overburden. Closure of the horizontal tunnel was anticipated both because of the vertical buttonhook emplacement of the device and the presence of a fault in the tunnel which was expected to cause collapse at that point. To prevent gases leaking through the tunnel and up the vertical shaft to the surface, a series of sand stems was used in the tunnel and in the lower portion of the shaft. The combination of these factors minimized the probability that venting would occur through the tunnel. Cracks, however, would be formed as a result of the detonation which might intersect existing faults in the immediate vicinity, this producing a possible means of escape for radioactivity. This mechanism was considered most probable for the maximum credible release. The material release would be inert gases - all particulates being removed before reaching the surface. The initial release would probably not take place immediately but would require several hours because of the long and indirect path to the surface. If venting of this nature occurred it was expected to continue for many hours. A modified form of Sutton's continuous point source diffusion equation was used to predict total exposures due to the vented radioactive gases.

Consideration was also given to the conseque. ˀes of immediate venting with the fraction of total activity out per unit time being similar to the Gnome event. This was considered to be an extremely unlikely occurrence. The estimated peak dose rates due to cloud passage would undoubtedly be conservative because of the differences in stemming.

It was assumed that 0.4% of the radionuclides Xe and Kr produced by the detonation would be released to the atmosphere over a 24-hour period beginning at H+6 hours and ending at H+30 hours. The hazard associated with these radionuclides is in the form of an external gamma dose and therefore total exposures due to the passing cloud of gases as a function of distance from ground zero was computed. Since the 24-hour release would occur during both a nighttime and a daytime atmosphere, a separate set of meteorological parameters was used to determine the exposure for each period and then totaled. This amounts to assuming that the mean wind directions would remain constant during the entire 24-hour period. It was further assumed that the meander of the plume would be confined to a very narrow 10° sector. These assumptions tend to make the estimate very conservative. Each Xenon and Krypton nuclide was examined separately and the total exposure at all distances produced by each nuclide was compared with the maximum permissible exposure as furnished by the Operational Safety Division, NVOO. The predicted total exposure to Xe^{135} produced the greatest hazard but it was approximately two orders of magnitude below the maximum permissible (1.7×10^{-2} cur-min/m^3) at a distance of five miles downwind, the radius of the exclusion area. This estimate is shown on Figure 3.7.

Peak dose rates due to cloud passage for the unlikely case of immediate venting are shown in Figure 3.8. A 3000-foot cloud layer, 30° of shear in the fallout hodograph and a mean layer wind speed of 10 mph was assumed. A hot line bearing of 135° was predicted. The nearest populated site downwind on this bearing is the town of Gabbs at a distance of 35 miles. At this distance it was estimated that the peak dose rate due to cloud passage would be 20 mr/hr.

The pre-shot vertical temperature structure is shown in Figure 3.9. This diagram indicates an inversion at approximately 2000 feet above the GZ surface, however, a 3000-foot cloud layer was used in the prediction computations. This is because the SHOAL Site terrain drops off a few miles downwind to a valley, the elevation of which is approximately 1000 feet lower than the SHOAL GZ, making the use of a 3000-foot cloud layer reasonable.

3.4 RADIATION VERIFICATION

No radioactive materials were released to the atmosphere as a result of detonating the SHOAL device. This was verified both by ground and aerial monitors.

CHAPTER IV

POST-SHOT ACTIVITIES

As pointed out in Section 3.4, no radioactive materials were released to the atmosphere as an immediate result of detonating the SHOAL device. Thus it seems logical to assume that leakage of radioactive gases through small cracks in the overburden, possibly produced by the detonation, might occur at some later time or that pockets of gases might be encountered during the drill-back operation.

For this reason it was necessary to provide meteorological support until December 14, 1963 at which time the project manager decided there was no longer a requirement.

The extent of the meteorological support provided was a function of the drill-back progress. Initially four wind soundings were taken each day at 0400, 1000, 1600, and 2200 PST. Although no formal weather forecasts were presented, intermittent monitoring of the weather was maintained and forecasts were provided on request. Facsimile weather transmissions, teletype data for winds aloft analysis, and the local wind tower information were utilized. A constant level balloon (tetroon) was kept ready at all times in case radioactive gases should be released to the atmosphere. This tetroon would be useful in determining the radioactivity trajectory.

When the drill-back had progressed sufficiently the weather station was manned continuously.

Temperature soundings were taken at 0400 and 1600 PST and radar winds were taken at 0400, 0700, 1000, 1200, 1600, 1900, and 0000 PST. Estimates of radioactive gas concentrations as a function of distance from the source and the trajectory of the radioactivity were provided upon request.

Upon completion of weather support requirements at the SHOAL site, plans were made to make ready and return all Weather Bureau equipment to the Nevada Test Site.

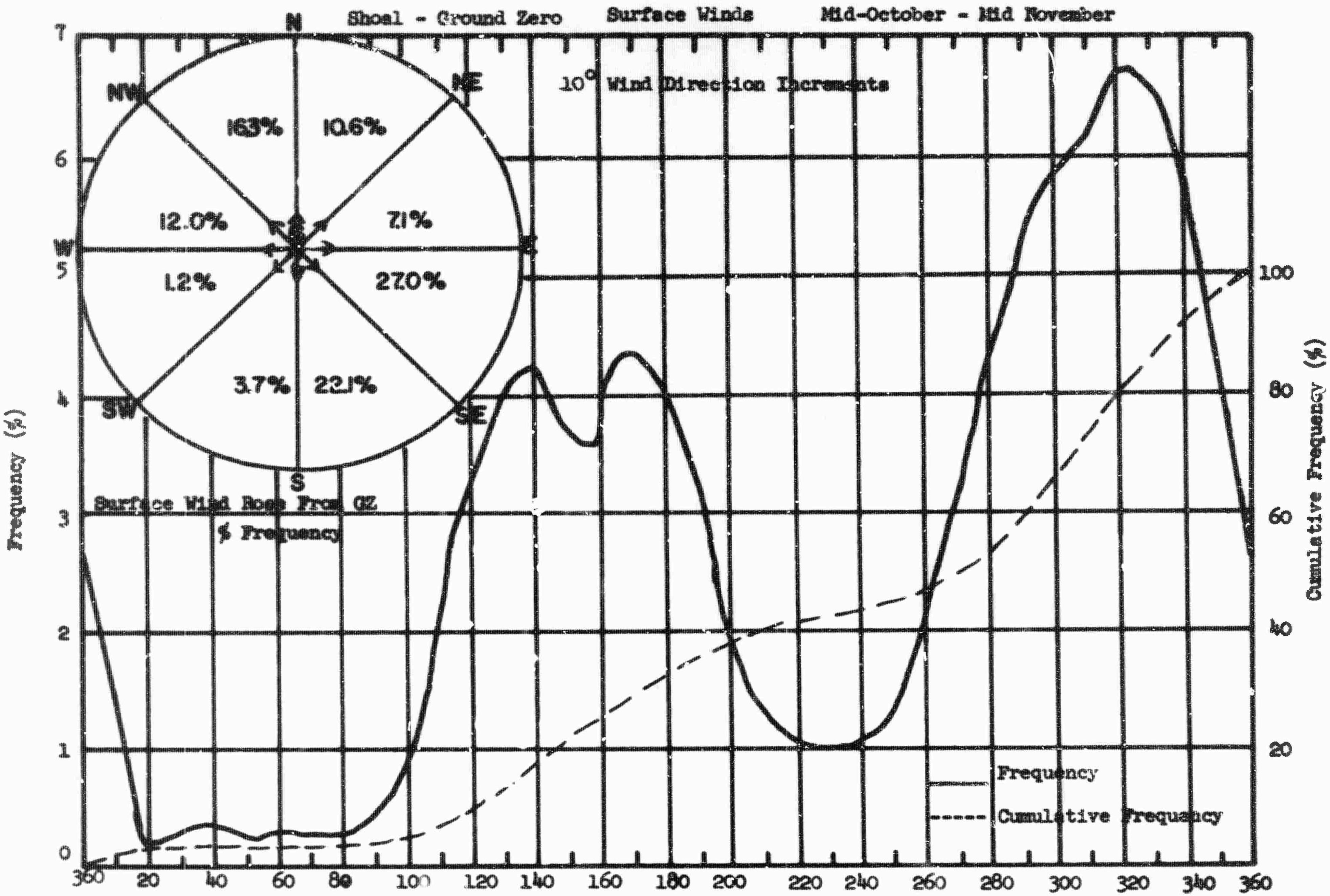
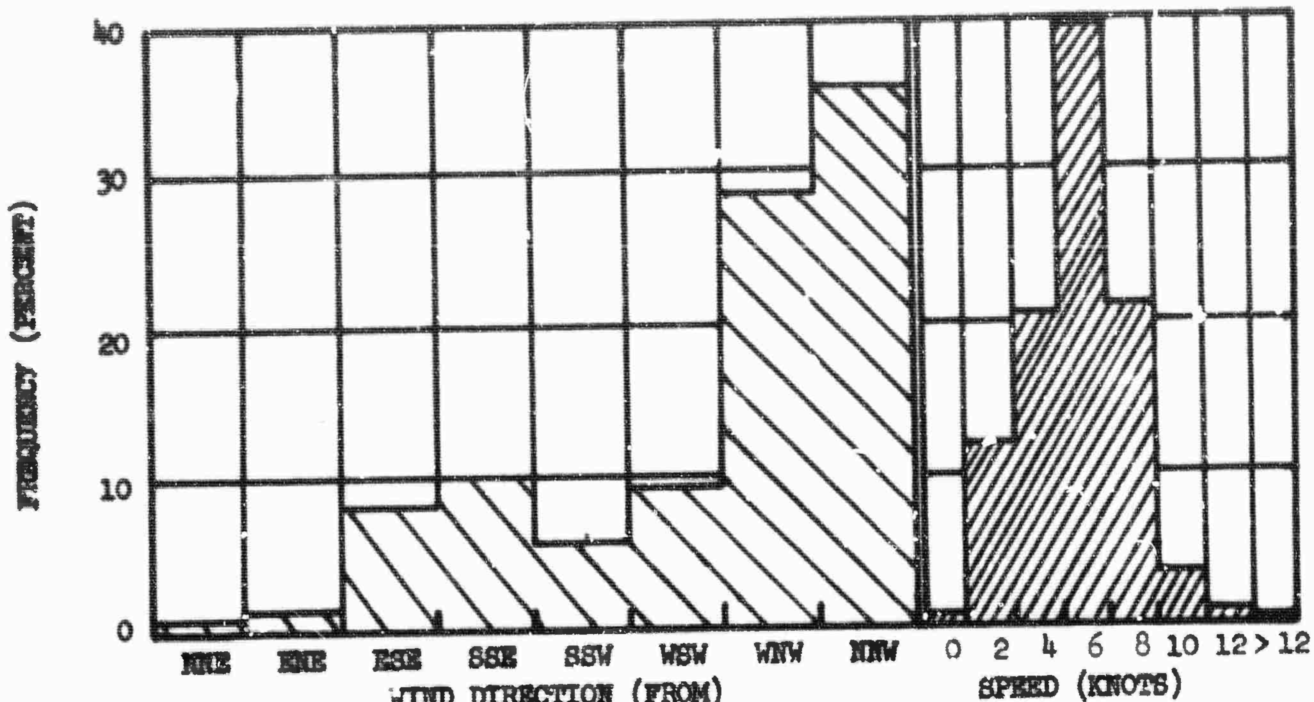

Shoal - Ground Zero
Surface Winds
Mid-October - Mid November
10° Wind Direction Increments
N
NE
E
SE
S
SW
W
NW
16.3%
10.6%
7.1%
27.0%
22.1%
3.7%
1.2%
12.0%
Surface Wind Rose From GZ
% Frequency
Frequency (%)
Cumulative Frequency (%)
Frequency
Cumulative Frequency
0
1
2
3
4
5
6
7
20
40
60
80
100
360
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

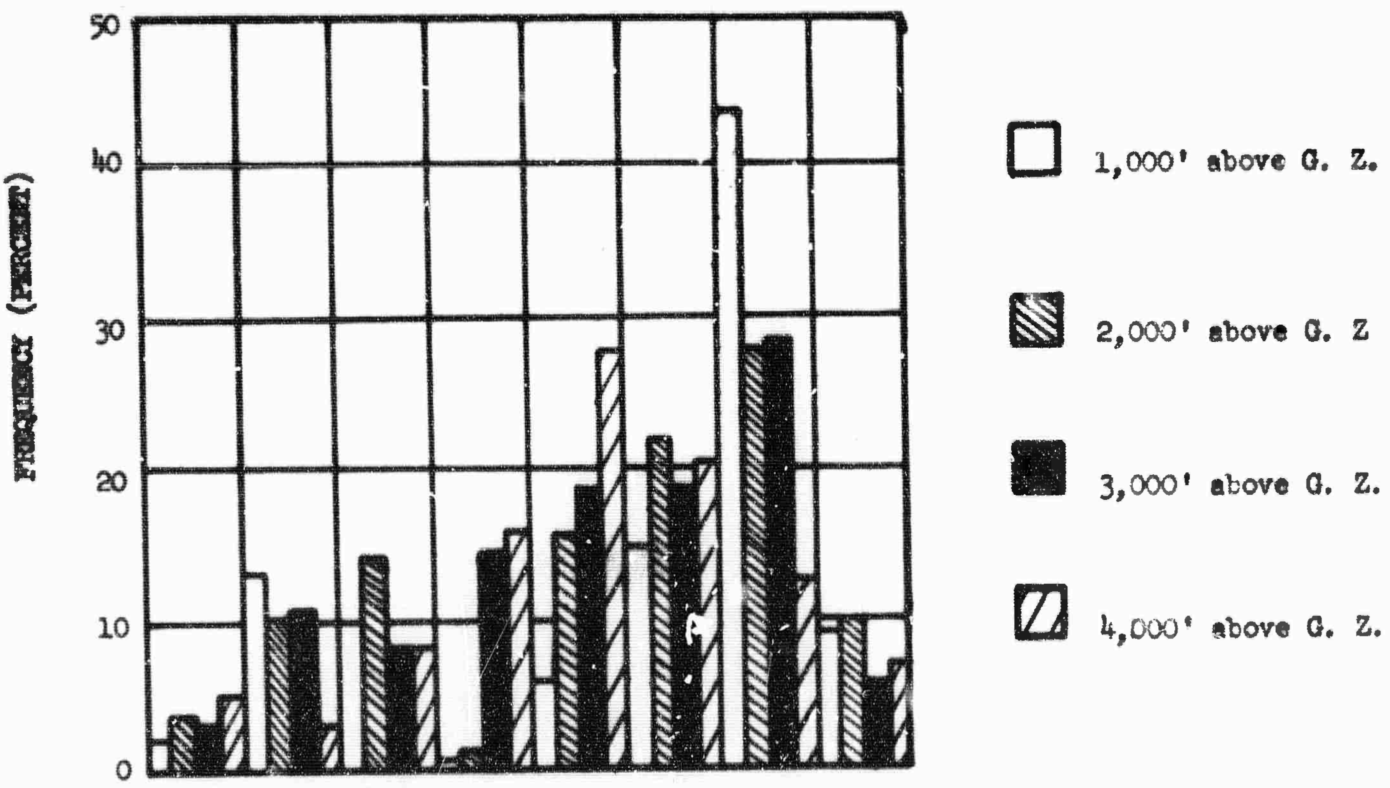
Figure 2.1

B. FREQUENCY GRAPHS SUMMER SEASON (May-September).



SURFACE WIND FREQUENCIES GROUND ZERO

Figure 2.2



UPPER WIND FREQUENCIES GROUND ZERO

Figure 2.3

BRIEFING FORECAST for 1330 (time) 25 October 1963 (date)

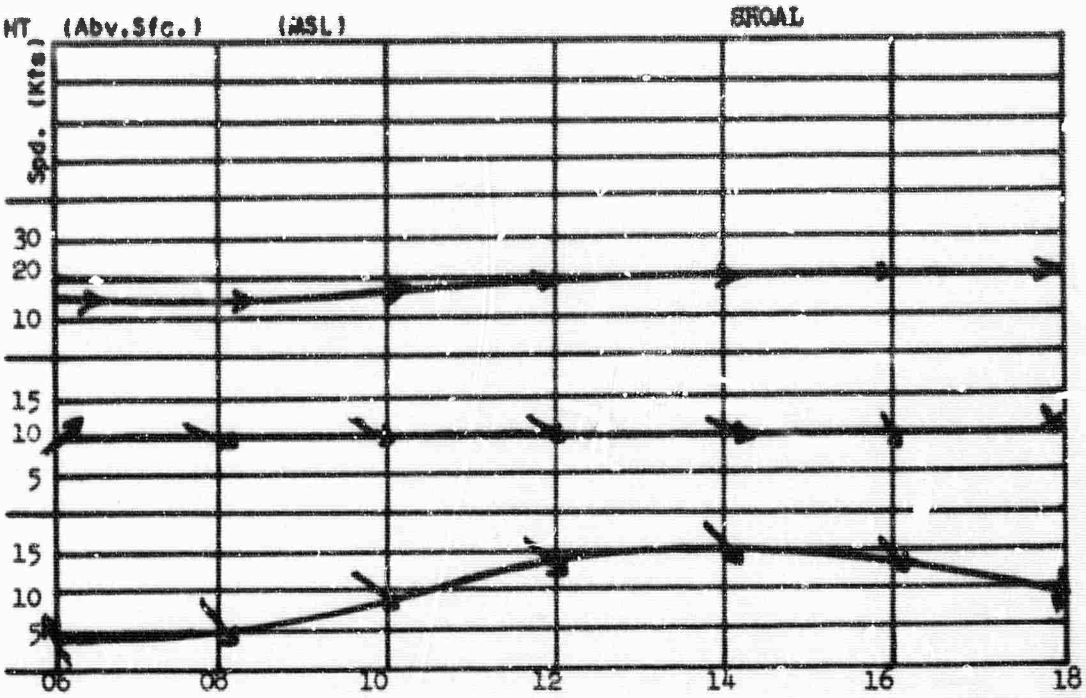
VALID from 0600 PST (time) 26 October (date) to 1800 PST (time) 26 October (date)

Latest Available Data 1200 Z (time) 25 October 1963 (date)

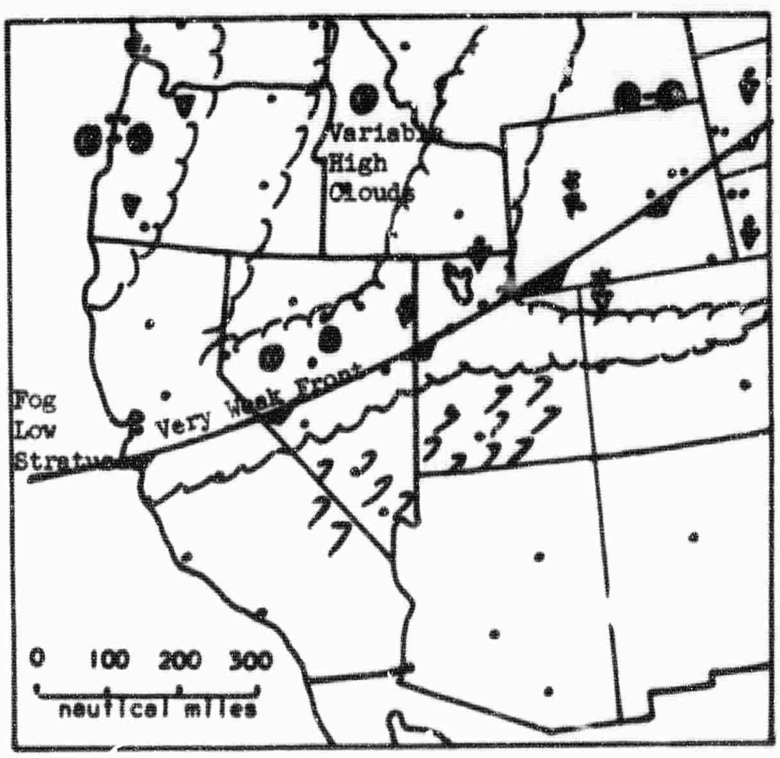
HEIGHT (Abv. Sfc.) (MSL)

HT	DIR	SPD
14	260	35
12	260	30
10	260	25
9	270	20
8	270	15
7	280	15
6	290	10
Sfc	310	5

WIND LADDER



VALID 26 October 1963 WIND TIME SECTIONAL (Time: 06-18 PST)



CLOUDS & WEATHER

VALID: 06-18 PST

26 Oct. 1963

Figure 2.4

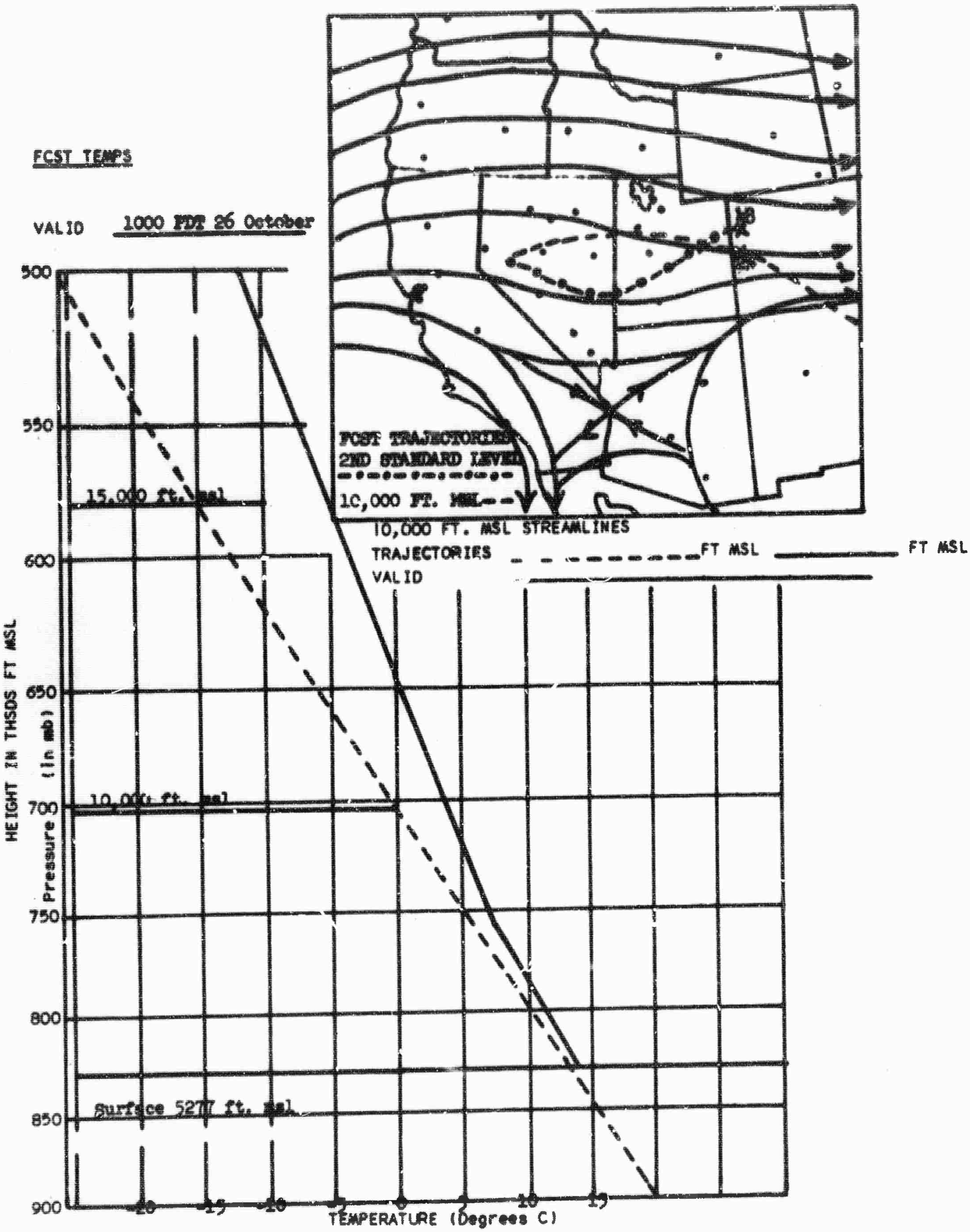
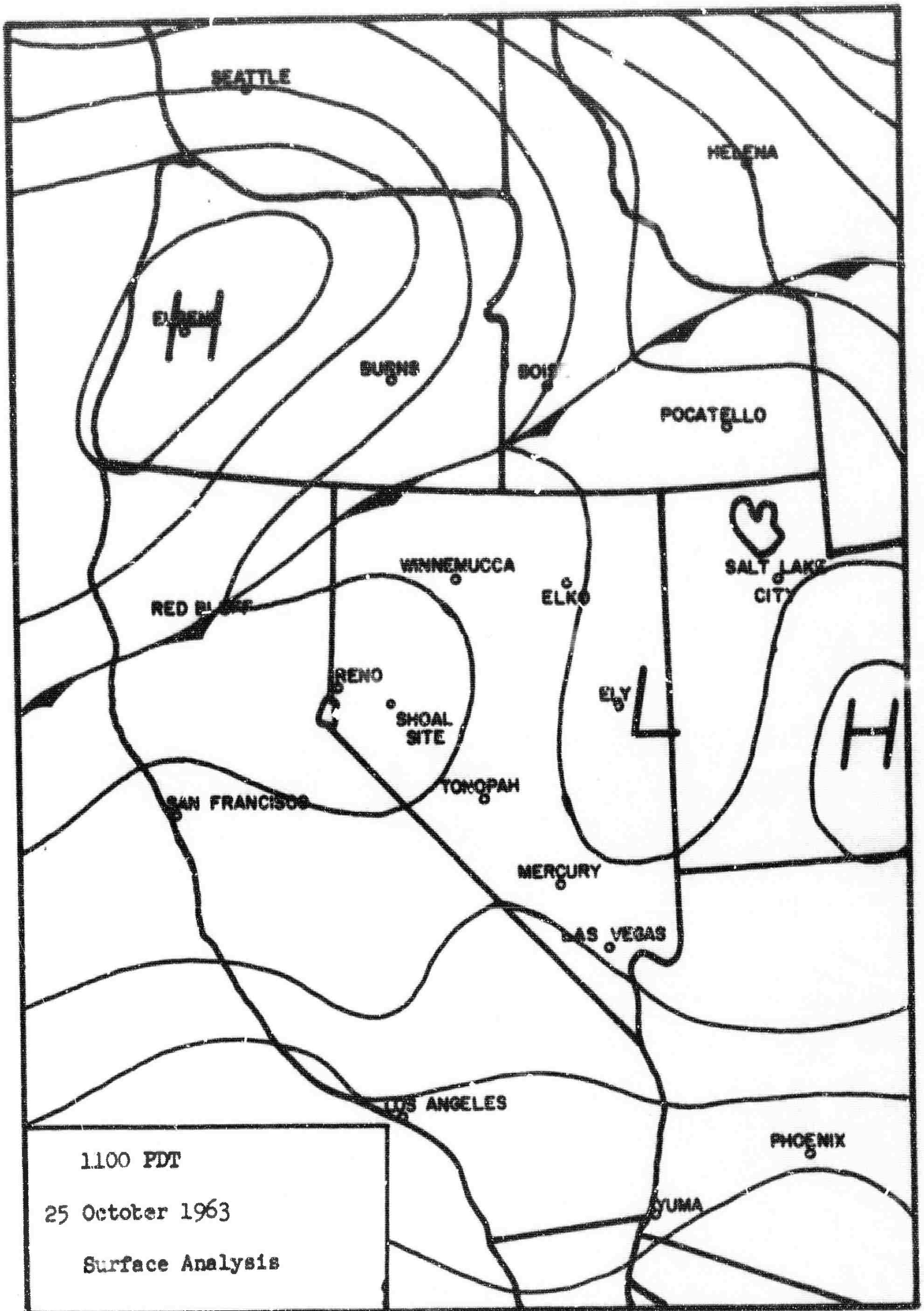

FCST TEMPS
VALID 1000 PDT 26 October
FCST TRAJECTORIES
2ND STANDARD LEVEL
10,000 FT. MSL
10,000 FT. MSL STREAMLINES
TRAJECTORIES FT MSL FT MSL
VALID
15,000 ft. msl
10,000 ft. msl
Surface 5277 ft. msl
500
550
600
650
700
750
800
850
900
HEIGHT IN THSDS FT MSL
Pressure (in mb)
-20
-15
-10
-5
0
5
10
15
TEMPERATURE (Degrees C)

Figure 2.5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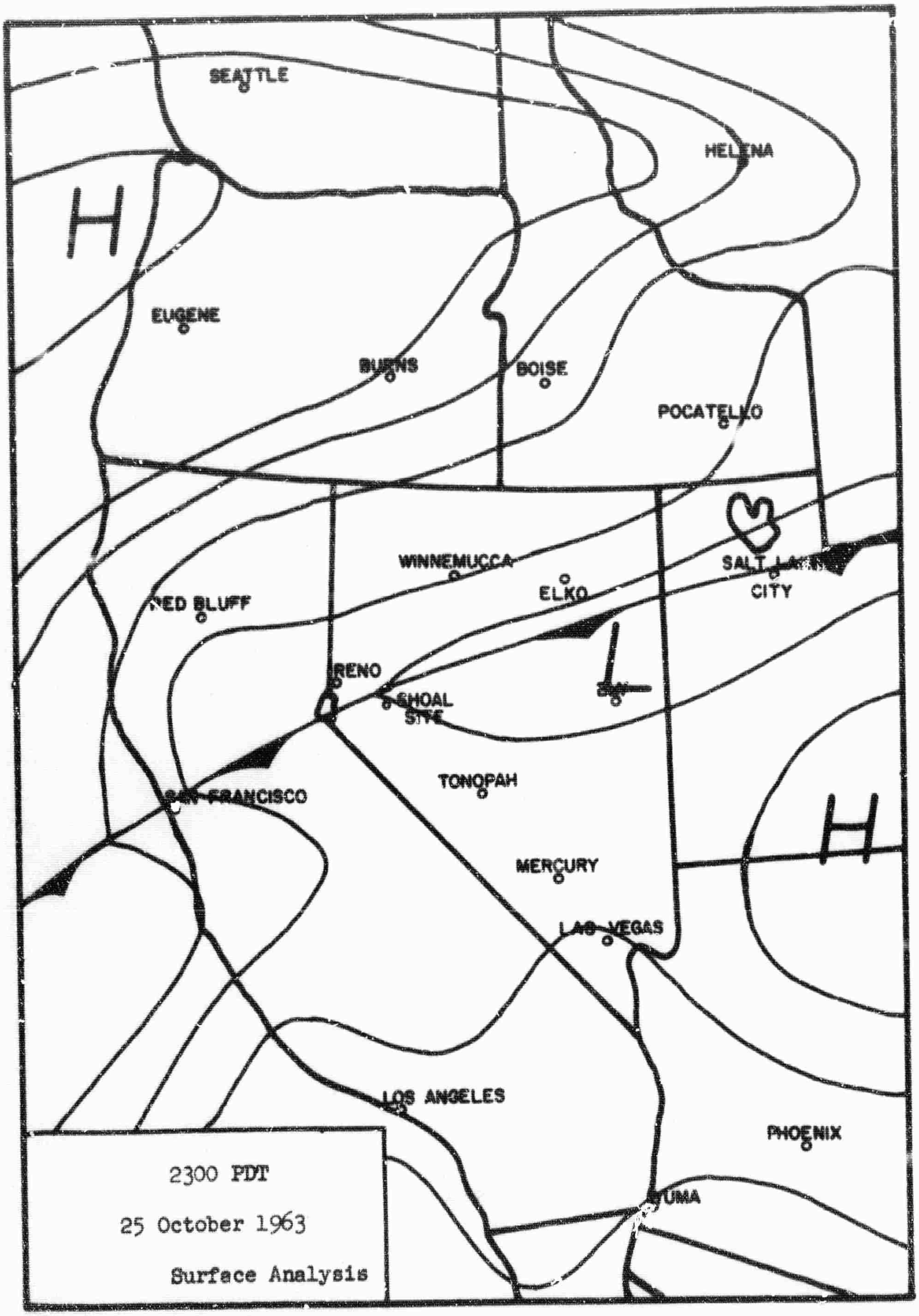
SALT LAKE
CITY
RED BLUFF
RENO
SHOAL
SITE
ELY
L
H
TONOPAH
SAN FRANCISCO
MERCURY
LAS VEGAS
LOS ANGELES
PHOENIX
YUMA
1100 PDT
25 October 1963
Surface Analysis

Figure 3.1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SITE
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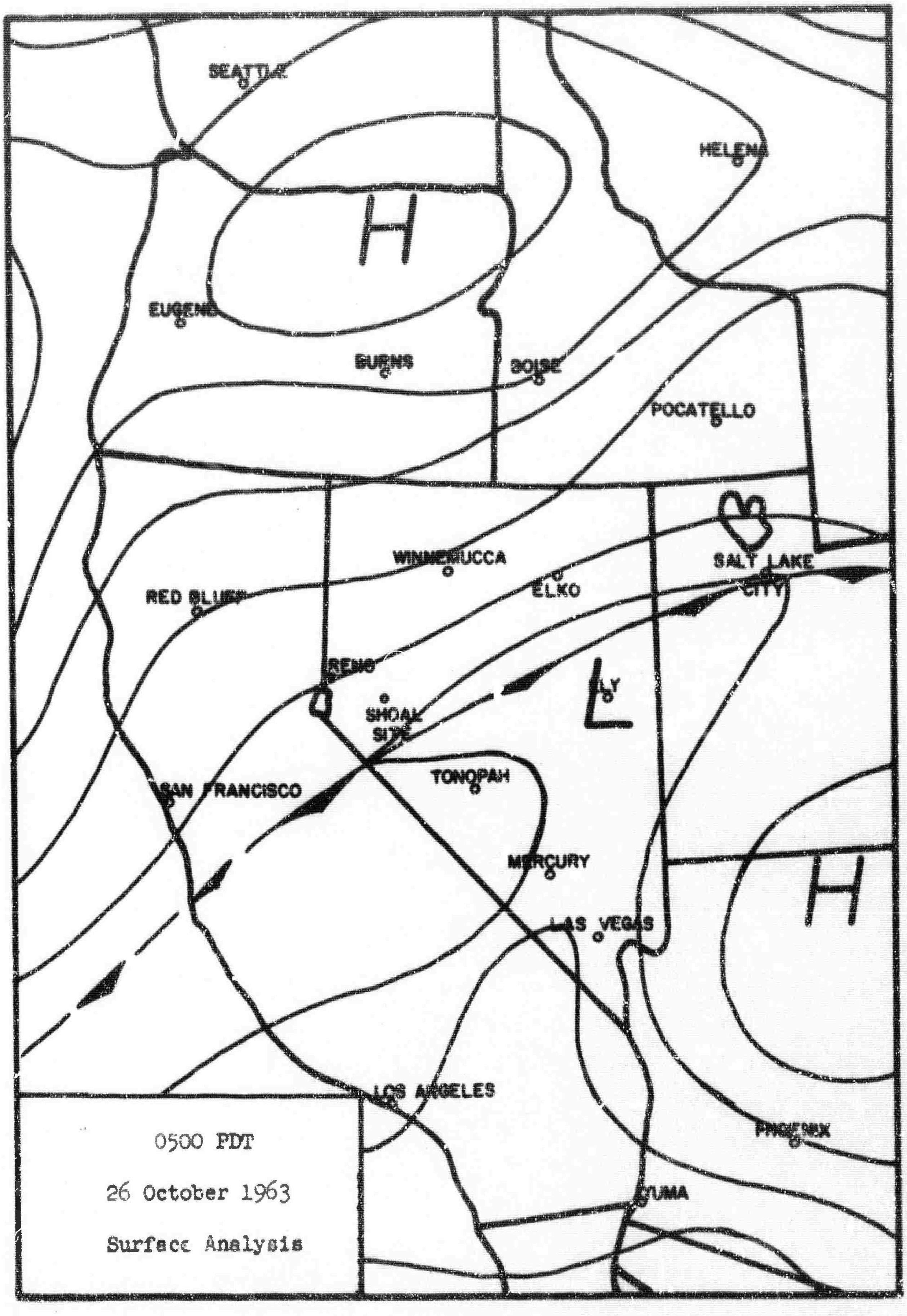
PHOENIX
YUMA
2300 PDT
25 October 1963
Surface Analysis

Figure 3.2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LAS VEGAS
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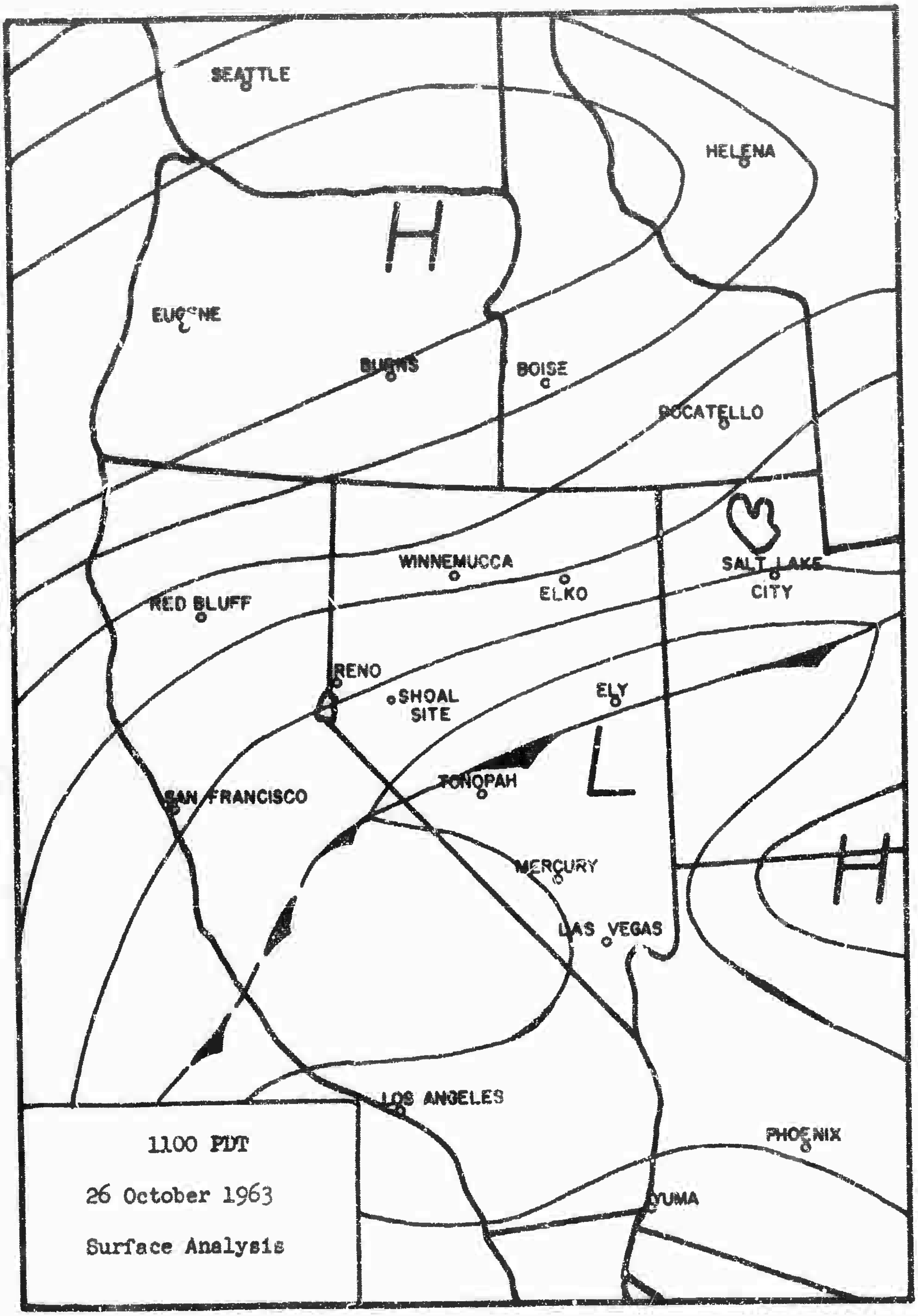
PHOENIX
YUMA
0500 PDT
26 October 1963
Surface Analysis

Figure 3.3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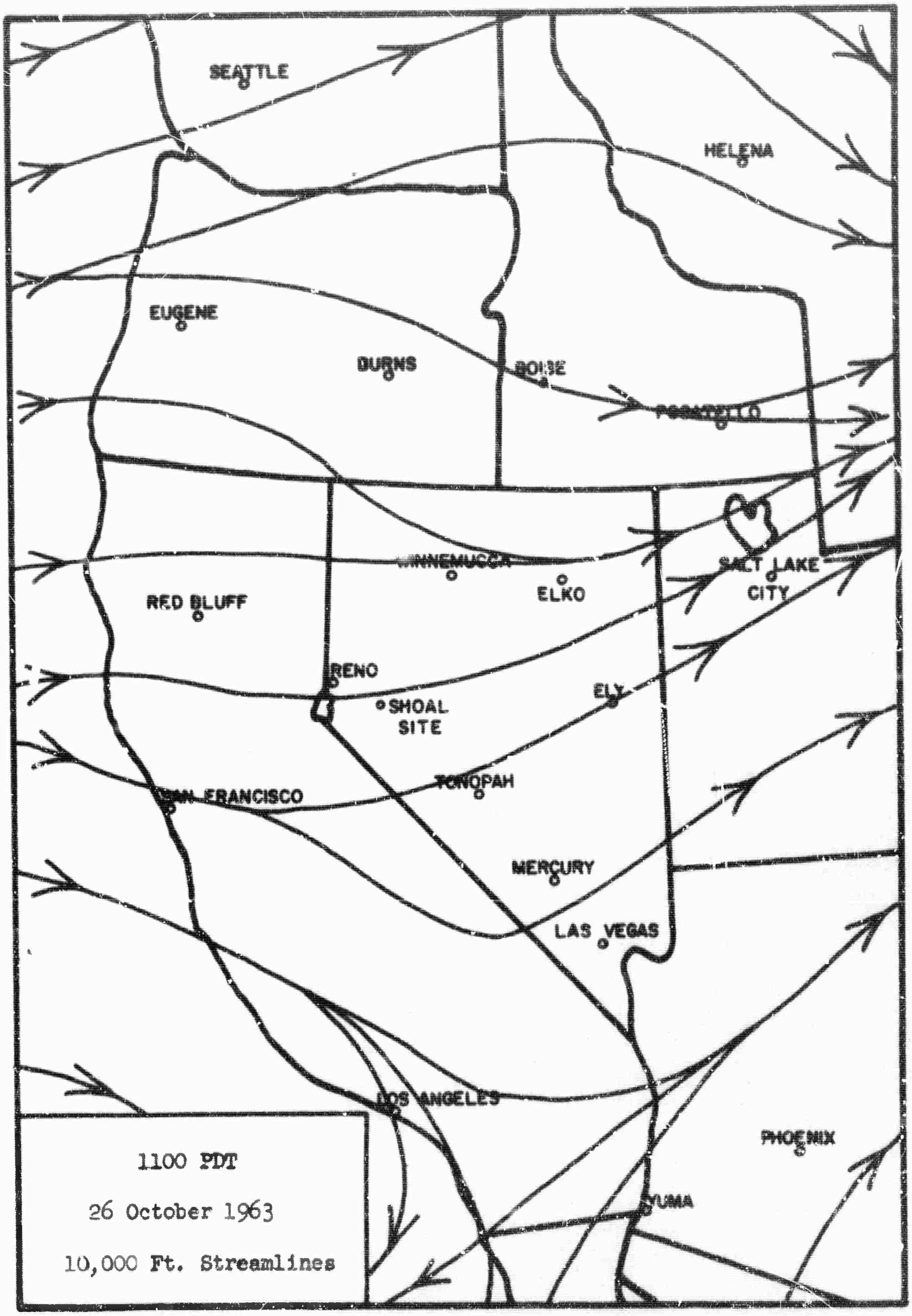
Surface Analysis

Figure 3.4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YUMA
1100 PDT
26 October 1963
10,000 Ft. Streamlines

Figure 3.5

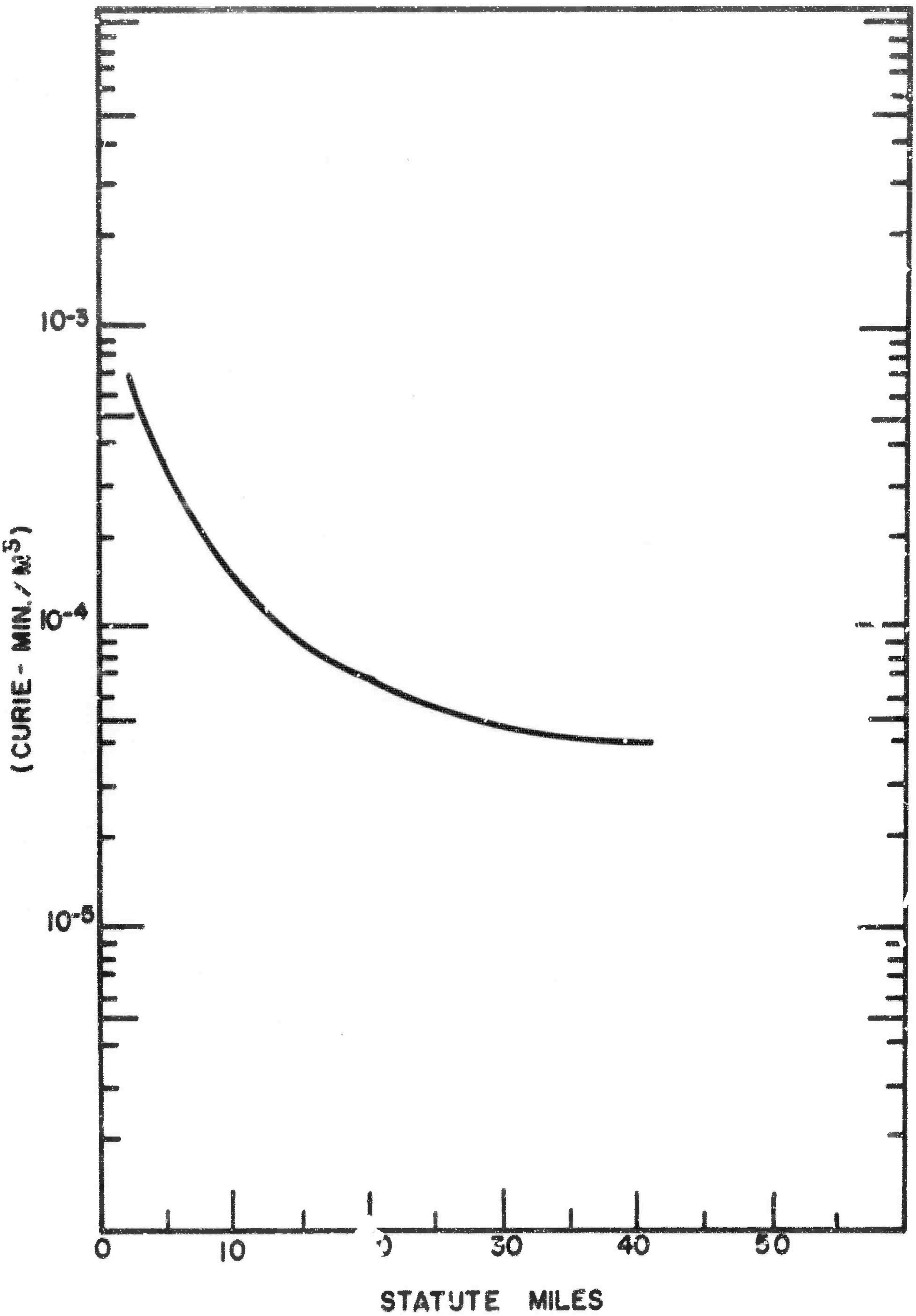

Figure 3.6 Graph of Predicted Total Exposure to Xe^{135}

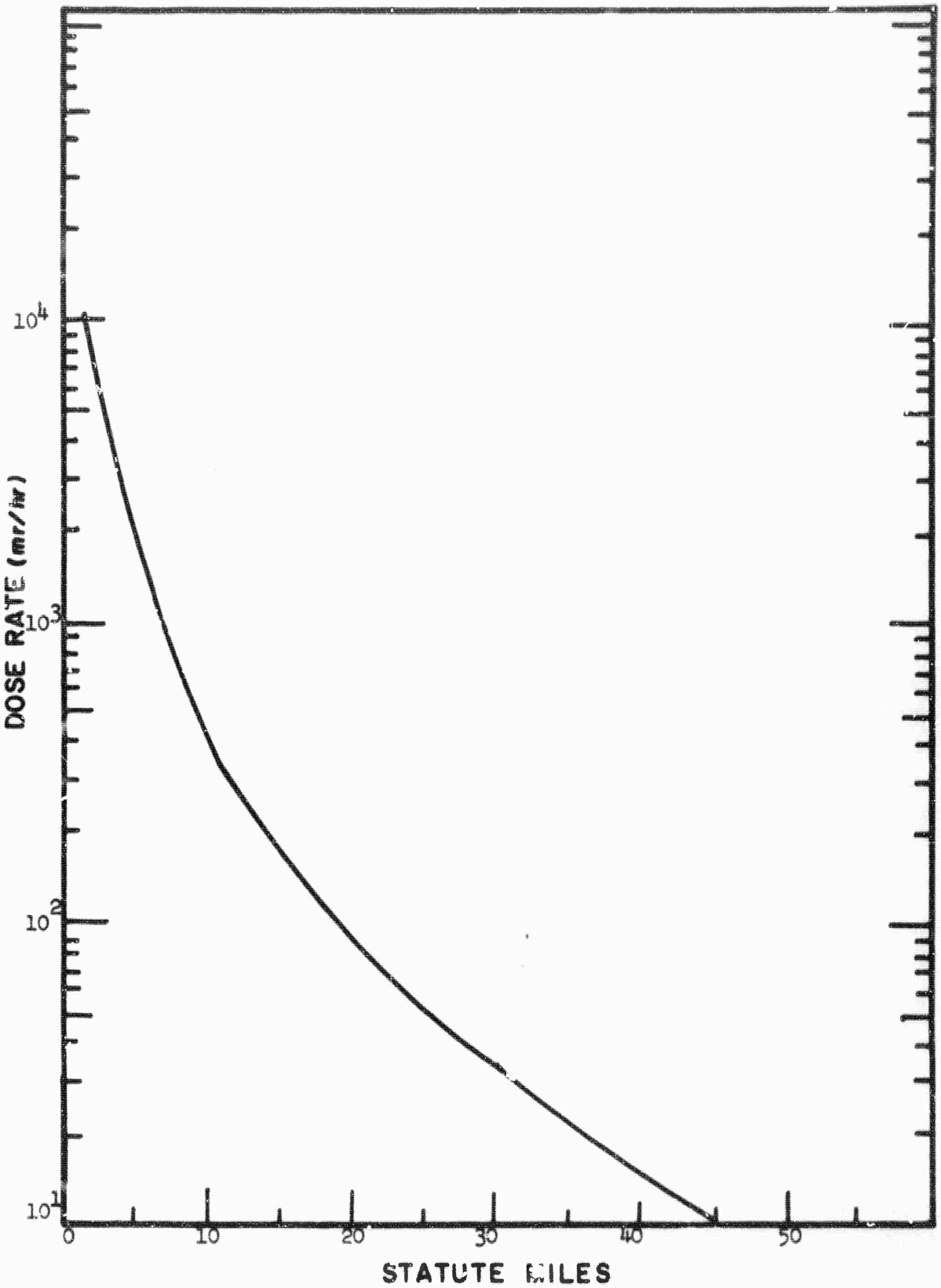

Figure 3.7 Graph of Predicted Peak Dose Rates Due to Cloud Passage

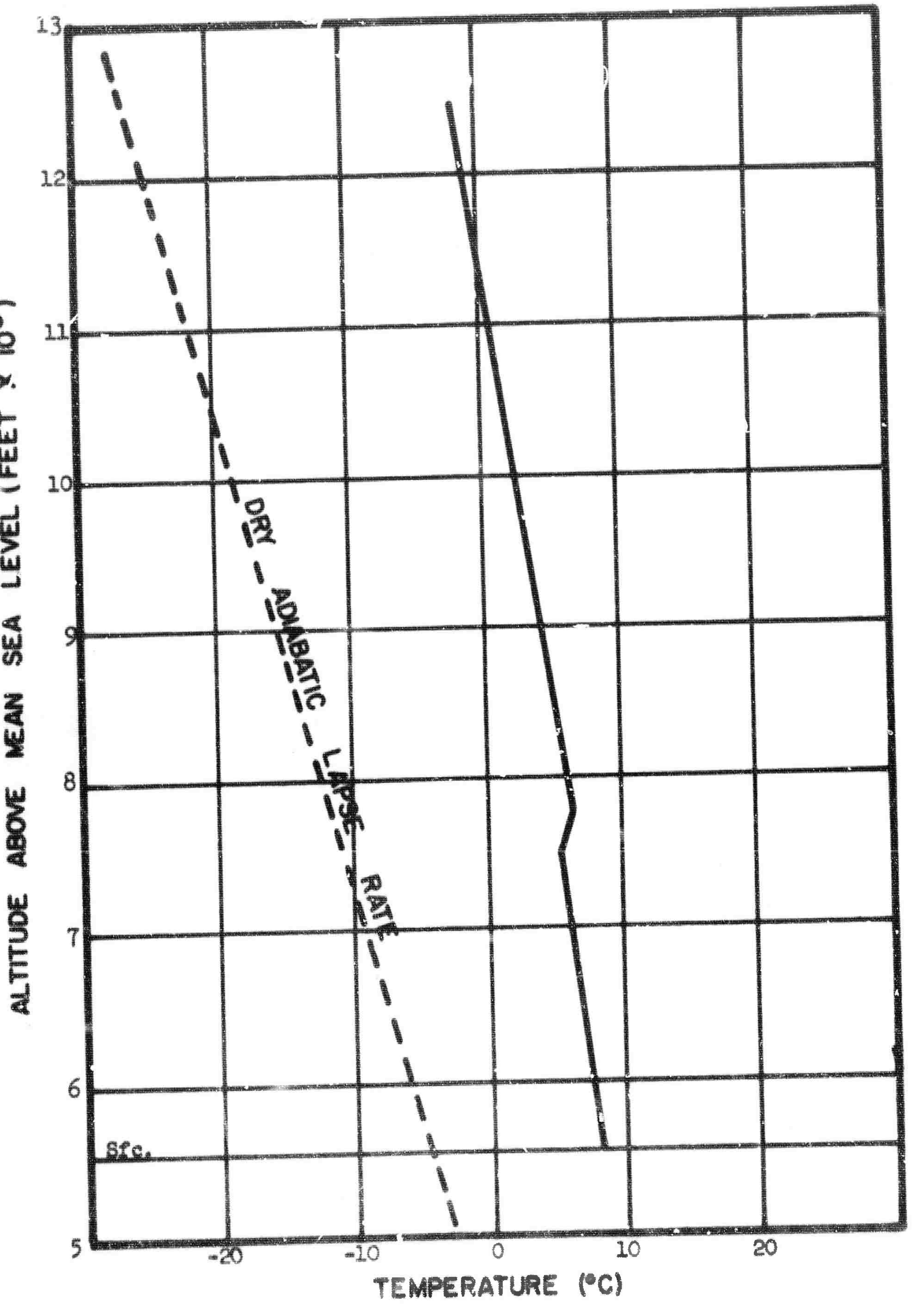

Figure 3.8 Actual Pre-Shot Temperature Profile.

TECHNICAL REPORTS SCHEDULED FOR ISSUANCE BY AGENCIES PARTICIPATING IN PROJECT SHOAL

AEC REPORTS

Agency	Report No.	Project No.	Subject or Title
NBM	VUF-1001	33.2	Geological, Geophysical and Hydrological Investigations of the Sand Springs Range, Fairview Valley and Fourmile Flat, Churchill County, Nevada
SC	VUF-1002	40.5	Seismic Measurements at Sandia Stations
SC	VUF-1003	45.3	Hydrodynamic Yield Measurements
SC	VUF-1004	45.5	Device Support, Arming, Stemming and Yield Determination
SC	VUF-1005	45.6	Radiological Safety
EG&G	VUF-1006	60.4	Final Timing and Firing Report - Final Photo Report
USBM-PRC	*		Subsurface Fracturing From Shoal Nuclear Detonation
USWB	VUF-1008		Weather and Surface Radiation Prediction
USPHS	VUF-1009		Off-Site Surveillance
USBM	VUF-1010		Structural Survey of Private Mining Properties
USC&GS	VUF-1011		Seismic Safety Net
REECo	VUF-1012		On-Site Health and Safety Report

Agency	Report No.	Project No.	Subject or Title
RFB, Inc.	VUF-1013		Analysis of Shoal Data on Ground Motion and Containment
H-NSC	VUF-1014		Shoal Post-Shot Hydrologic Safety Report
H&N	VUF-1015		Pre-Shot and Post-Shot Structure Survey
H&N	VUF-1016		Test of Dribble-Type Structures
FAA	VUF-1017		Federal Aviation Agency Airspace Advisory
		DOD REPORTS	
SC	VUF-2001	1.1	Free Field Earth Motions and Spalling Measurements in Granite
SC	VUF-2002	1.2	Surface Motion Measurements Near Surface
** USC&GS	VUF-2300	1.4	Strong Motion Seismic Measurements
LPI	VUF-2600	1.6	In-Situ Stress in Granite
** STL	VUF-2400	1.7	Shock Spectrum Measurements
SRI	VUF-3001	7.5	Investigation of Visual and Photographic On-Site Techniques
SRI	VUF-3002	7.6	Local Seismic Monitoring - Vela CLOUD GAP Program

TI	VUF-3003	7.8	Surface and Subsurface Radiation Studies
USGS	VUF-3004	7.9	Physical and Chemical Effects of the Shoal Event
ITEK	VUF-3005	7.10	Airborne Spectral Reconnaissance
BR Ltd.	VUF-3006	7.15	The Mercury Method of Identification and Location of Underground Nuclear Sites
NRDL	VUF-3007	7.16	Multi-Sensor Aerial Reconnaissance of an Underground Nuclear Detonation
GIMRADA	VUF-3008	7.17	Stereophotogrammetric Techniques for On-Site Inspection
ISOTOPES	VUF-3009	7.19	Detection in Surface Air of Gaseous Radionuclides from the Shoal Underground Detonation
*** USC&GS		8.1	Microearthquake Monitoring at the Shoal Site
**** GEO-TECH		8.4	Long-Range Seismic Measurements

* This is a Technical Report to be issued as PNE-3001 which will receive TID-4500 category UC-35 Distribution "Nuclear Explosions-Peaceful Applications"

** Project Shoal results are combined with other events, therefore, this report will not be printed or distributed by DTIE

*** Report dated March 1964 has been published and distributed by USC&GS

**** Report dated December 9, 1963, DATDC Report 92, has been published and distributed by UED

LIST OF ABBREVIATIONS FOR TECHNICAL AGENCIES

BR Ltd.	Barringer Research Limited Rexdale, Ontario, Canada
EG&G	Edgerton, Germeshausen & Grier, Inc. Boston, Massachusetts Las Vegas, Nevada Santa Barbara, California
FAA	Federal Aviation Agency Los Angeles, California
GEO-TECH	Geo Technical Corporation Garland, Texas
GIMRADA	U. S. Army Geodesy, Intelligence and Mapping Research and Development Agency Fort Belvoir, Virginia
H-NSC	Hazleton-Nuclear Science Corporation Palo Alto, California
H&N, Inc.	Holmes & Narver, Inc. Los Angeles, California Las Vegas, Nevada
ISOTOPES	Isotopes, Inc. Westwood, New Jersey
ITEK	ITEK Corporation Palo Alto, California
LPI	Lucius Pitkin, Inc. New York, New York
NBM	Nevada Bureau of Mines University of Nevada, Reno, Nevada
NRDL	U. S. Naval Radiological Defense Laboratory San Francisco, California
REECo	Reynolds Electrical & Engineering Co., Inc. Las Vegas, Nevada
SC	Sandia Corporation Albuquerque, New Mexico
SRI	Stanford Research Institute Menlo Park, California

RFB, Inc.	R. F. Beers, Inc. Alexandria, Va.
STL	Space Technology Laboratories, Inc. Redondo Beach Park, California
TI	Texas Instruments, Inc. Dallas, Texas
USBM	U. S. Bureau of Mines Washington, 25, D. C.
USBM-PRC	U. S. Bureau of Mines Bartlesville Petroleum Research Center Bartlesville, Oklahoma
USC&GS	U. S. Coast and Geodetic Survey Las Vegas, Nevada
USGS	U. S. Geologic Survey Denver, Colorado
USPHS	U. S. Public Health Service Las Vegas, Nevada
USWB	U. S. Weather Bureau Las Vegas, Nevada